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IS : 6158 - 1984  
REAFFIRMED

*Indian Standard*

RECOMMENDED PRACTICE FOR  
SAFEGUARDING AGAINST EMBRITTLEMENT OF  
HOT-DIP GALVANIZED IRON AND  
STEEL PRODUCTS

*( First Revision )*

UDC 669.1.015 . 669.586.5 . 620.192.49



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MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG  
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**AMENDMENT NO. 1 JUNE 1999**  
**TO**  
**IS 6158 : 1984 RECOMMENDED PRACTICE FOR**  
**SAFEGUARDING AGAINST EMBRITTLEMENT OF**  
**HOT-DIP GALVANIZED IRON AND STEEL PRODUCTS**  
*( Second Revision )*

*( Page 4, clause 1.1 )* — Substitute the following for the existing clause:

**'1.1 This standard prescribes factors which are responsible for causing embrittlement in steel products during galvanizing process and procedure for detecting embrittlement and to safeguard against them.'**

*( Page 4, clause 2 )* — Insert the following new clauses and renumber the subsequent clauses:

**'2 TERMINOLOGY**

**2.1 Embrittlement** — It is the total or partial loss of ductility in steel. An embrittled product characteristically fails by fracture without appreciable deformation. Types of embrittlement usually encountered in galvanized steel are related to ageing phenomena, cold working and absorption of hydrogen.'

*[ Page 4, clause 2.1 ( renumbered 3.1 ) ]* — Substitute the following for the existing Clause:

**'2.1 Base Metal( Steels)** — Only steels produced by open hearth, basic oxygen and electric furnace shall be used for galvanizing. Basic open-hearth or basic electric steel should always be specified with carbon and phosphorus content being as low as practicable. Bessemer steels should never be used where the material is cold formed and not subsequently annealed prior to galvanizing. Carbon should not exceed 0.25 percent where severe cold-forming operations precede galvanising.'

*[ Page 5, clause 2.2.3 ( renumbered 3.2.3 ) ]* — Substitute the following for the existing clause:

**'2.2.3 The smaller hot rolled shapes including thicknesses up to 6 mm , may be cold worked by punching without subsequent annealing or stress relieving. Shapes 8 mm to 17 mm in thickness are not seriously affected as to serviceability**

**Amend No. 1 to IS 6158 : 1984**

by cold working in punching. The heavier shapes, 18 mm and over, should be reamed or drilled after punching or suitably thermally treated prior to galvanising.'

[ Page 6, clause 3.2.2.1 ( *renumbered 4.2.2.1* ) ] — Substitute '25 mm' for '2.5 mm'.

( MTD 20 )

# *Indian Standard*

## RECOMMENDED PRACTICE FOR SAFEGUARDING AGAINST EMBRITTLEMENT OF HOT-DIP GALVANIZED IRON AND STEEL PRODUCTS

*( First Revision )*

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## *Indian Standard*

# RECOMMENDED PRACTICE FOR SAFEGUARDING AGAINST EMBRITTLEMENT OF HOT-DIP GALVANIZED IRON AND STEEL PRODUCTS

*( First Revision )*

## 0. F O R E W O R D

**0.1** This Indian Standard ( First Revision ) was adopted by the Indian Standards Institution on 20 December 1984, after the draft finalized by the Hot-Dip, Sprayed and Diffusion Coatings Sectional Committee had been approved by the Structural and Metals Division Council.

**0.2** This standard was earlier published in 1971. In this revision, the embrittlement test for small galvanized articles has been modified, keeping in view of the experience gained since the last publication of the standard.

**0.3** Embrittlement of galvanized steel means the loss of ductile properties of steel during galvanizing. It may be partial or complete and seldom manifests itself except at points which have been cold-worked, for example, by punching; the effect is noted in specimens with stress concentration, such as is caused by notches, holes, fillets of small radii and sharp bends.

**0.4** Galvanizing embrittlement of steel is primarily a form of strain ageing. Such embrittlement occurs because of exposure to the temperature incident to the application of zinc coating on steels which are susceptible to strain ageing as a result of strains induced by cold-work. Embrittlement can also occur as a result of hydrogen absorption in pickling as described in 2.3.

**0.5** Strain ageing denotes changes taking when the final operation consists of cold-working. Ageing may result in an increase in hardness and strength, a loss in ductility and impact resistance; the reappearance of a sharply defined yield point in the stress-strain curve of a tension test, and similar changes in other properties. The ageing changes proceed relatively slow at room temperature, but at an accelerated rate as the ageing temperature is raised.

## **1. SCOPE**

**1.1** This standard prescribes various factors which are responsible for causing embrittlement in steel products during galvanizing process and procedure to safeguard against them.

## **2. FACTORS IN EMBRITTLEMENT**

**2.1 Base Metal ( Steels )** — Only steels produced under the trade designation of open-hearth, basic oxygen, and electric-furnace shall be used for galvanizing if any cold-working without subsequent annealing or stress-relieving is to precede galvanizing. Basic open-hearth or basic-electric steel should always be specified with carbon and phosphorus contents being as low as practicable. Bessemer steels should never be used where the material is cold-formed and not subsequently annealed prior to galvanizing. Steels should not exceed 0.25 percent carbon content where severe cold-forming operations precede galvanizing.

**2.1.1** Steels vary in their susceptibility to galvanizing embrittlement. Aluminium-killed steels are least susceptible to embrittlement, while the difference between semi-killed and silicon-killed steels is not precise. Rimmed steels are subject to embrittlement during galvanizing, particularly where heavy sections and sharp bends are involved.

**2.1.2** Coarse grained steels are more susceptible to embrittlement than fine grained steels. To maintain high resistance to impact after cold-working, aluminium-killed steels should be chosen and they should be normalized after rolling to become fine grained. The impact resistance of semi-killed and rimmed steels may also be increased by normalizing after rolling.

**2.1.3** Malleable and nodular iron will be decidedly embrittled by heating to 454°C as in galvanizing. The chemical composition of the iron castings, particularly the phosphorus and silicon content, is an important factor in galvanizing embrittlement. Prolonged annealing and slow cooling of malleable iron tend to make it more susceptible to subsequent embrittlement.

**2.1.4** Castings shall be of such composition that will preclude the possibility of embrittlement within their service temperature range, caused by galvanizing. Otherwise, they should be immunized against galvanizing embrittlement by rapid cooling from 676°C, preferably by water-quenching.

**2.1.5** The design of the product, the selection of the proper steel and method of fabrication to withstand normal galvanizing operations without embrittlement is the responsibility of the fabricator. Except where the design, the selection of the steel and the method of fabrication

is specified by the purchaser, it is the responsibility of the fabricator to select suitable steel which will withstand normal galvanizing operations.

## 2.2 Cold-Working

**2.2.1** The physical properties of steels are changed by cold-working. Thus hardness is increased and shock resistance is decreased. Cold-working may be of the nature of rolling, bending, upsetting, punching, shearing, etc. Any form of cold-working reduces the ductility of steel.

**2.2.2** For intermediate and heavy shapes, plates and hardware, any severe cold-working operations should subsequently be followed by annealing or stress-relieving. In the galvanizing operation there is no injurious loss of ductility unless the material has previously received severe localized cold-working.

**2.2.3** The smaller hot-rolled shapes including thicknesses up to 6 mm, may be cold-worked by punching without subsequent annealing or stress-relieving. Shapes 8 mm to 17 mm in thickness are not seriously affected as to serviceability by cold-working in punching. The heavier shapes, 18 mm and over, should be reamed or drilled after punching.

**2.2.4** It is the responsibility of the fabricator to ensure that residual stresses caused by cold-working are sufficiently relieved or are such that subsequent galvanizing operations will not result in embrittlement of the steel.

## 2.3 Pickling Practice

**2.3.1** Hydrogen absorption in the pickling process has a major effect on reducing the ductility of the steel. Surface roughness resulting from the pickling operation is a further cause of the loss in ductility. The previous treatment of steel, for example by cold-working, determines the magnitude of the effect to a large extent. Increasing the temperature of the pickling bath, as well as prolonging the immersion period, increases the resulting embrittlement.

**2.3.2** Complete recovery from the effect of hydrogen embrittlement may be achieved by prolonged heating of the articles at 150°C after pickling.

**2.3.3** It is the responsibility of the galvanizer to ensure that the steel to be galvanized is not overpickled either by excessively high pickling temperatures or by long immersion periods.

**NOTE 1** — Use of inhibitors in pickling bath may minimize etching and embrittlement.

**NOTE 2** — Hot alkaline cleaning or anodic acid etching baths may be used instead of acid pickling to avoid hydrogen embrittlement.

**2.4 Shot-Blasting** — Shot or sand blasting may be used on some products instead of pickling to avoid hydrogen embrittlement.

### **3. EMBRITTLEMENT TEST**

**3.0** If desired by the purchaser, the following embrittlement tests may be carried out.

#### **3.1 Small Galvanized Articles**

**3.1.1** Subject to base material and dimensional limitations, the tests given in **3.1.1.1** and **3.1.1.2** shall apply.

**3.1.1.1** A convenient bend test for embrittlement of galvanized steel hardwares, such as, bolts, pole and tower steps, insulator devices, braces, rods, etc, consists of clamping one end of the article in a vice and bending the other end through 90°. A suitable length of pipe may be used as a lever. An embrittled article will not withstand a 90° bend, whereas an article in the manufacture of which proper precautions against embrittlement have been taken will withstand such bending. If such a test is made on threaded articles, it shall be made on the unthreaded portion.

**3.1.1.2** Castings and steel hardware, of such shape and size that they do not permit bending, may be struck a sharp blow with a 1-kg hammer. If the material is not embrittled, it should not crack under such a blow.

#### **3.2 Galvanized Angles Test**

**3.2.1** The elongation measured in accordance with **3.2.3.1** shall be not less than 5 percent. When the specimen does not show 5 percent elongation, the reduction in thickness shall be measured in accordance with **3.2.2.2**. The sum of the percentage of elongation plus the average percentage reduction of thickness shall not be less than 10.

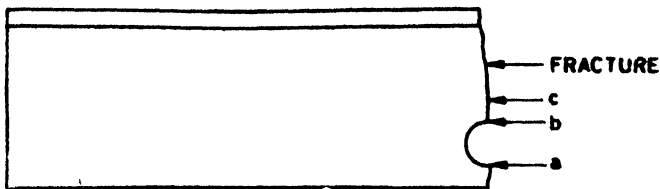
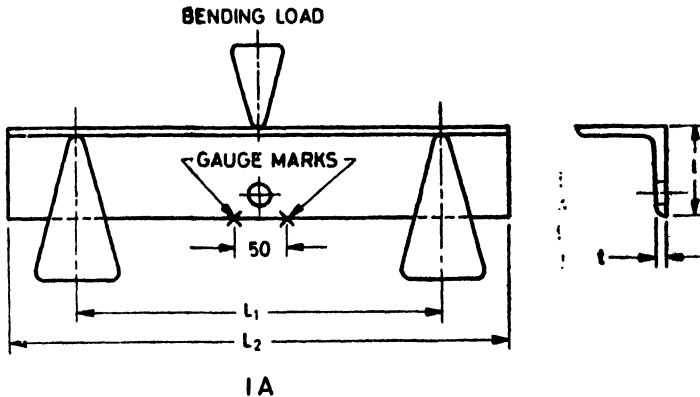
##### **3.2.2 Test Procedure**

**3.2.2.1** For determining the elongation after fracture, 50 mm gauge length ( Fig. 1A ) shall be prick-punched in the middle of the edge of the vertical leg of the angle along a line parallel to its length and centred directly under the hole. After the test, the sum of the distances along this line from each punch mark to the corresponding edge of the fracture shall be measured to 0.25 mm, with a flexible scale and the percentage of elongation calculated. For specimens under 12 mm in thickness, or those in which the distance from the edge of the hole to the edge of the angle is less than 10 mm the elongation shall be measured over a 2.5 mm gauge length.

**3.2.2.2** For determining the percentage reduction of the thickness after fracture, the reduction shall be measured with a ball-point micrometer at the three locations indicated in Fig. 1B, namely, *a*, outer side of hole; *b*, inner side of hole; *c*, middle of leg. The percentage reduction of thickness shall be calculated on the basis of the original thickness of the angle and the average of the three values at *a*, *b* and *c*.

**3.2.2.3** The length of the test specimen and the distance between the supports are given below:

<i>Leg of Angle</i>	<i>Length Between Support, <math>L_1</math></i>	<i>Minimum Length, <math>L_2</math></i>
mm	mm	mm
Up to and including 100	350	460
Over 100 up to and including 150	510	610
Over 150 up to and including 200	760	915



All dimensions in millimetres.

**FIG. 1 GALVANIZED ANGLE TEST**

**3.2.2.4** The kind of hole, punched, subpunched and reamed, or drilled shall be that employed in the fabricated material which the specimen represents. The dimensional values, diameter, and location of hole, shall be not less than those employed in the structural details. Care should be taken not to place the hole near stamped or rolled-in identification mark.

**3.2.2.5** The test shall be made upon galvanized specimens having a temperature not below 15°C and not over 32°C when tested.

**3.2.2.6** The test may be made in a universal testing machine.

**3.2.3** *Number of Tests* — One test from each thickness of angle from each melt of steel shall be made. In case there is a reasonable doubt that the angles represented by the specimens in the first test are not free of injurious embrittlement, two additional test shall be made, and if no failure to meet the requirements of 3.2.1 occurs in either of these tests the angles represented shall be considered acceptable.



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